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Present and future trends in pellet markets, raw materials, and supply logistics in Sweden and Finland

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ABSTRACT

Wood pellets have become an important fuel in heat and power production, and pellet markets are currently undergoing rapid development. In this paper, the pellet markets, raw materials and supply structures are analyzed for Sweden and Finland, based on a database of the current location and production capacity of the pellet producers, complemented with existing reports and literature. In Sweden, a total of 94 pellet plants/producers were identified, producing 1.4 million tonnes of pellets, while the domestic consumption was 1.7 million tonnes, and about 400,000 t of pellets were imported to fulfil the demand in 2007. In Finland, 24 pellet plants/producers were identified and the production was around 330,000 t while the domestic consumption was 117,000 t in 2007. In Finland, pellet market has been long time export oriented, whereas domestic consumption has been growing mainly in the small scale consumer sector, estimated 15,000 households had pellet heating systems in 2008. In the future, the increasing number of pellet users will require a reliable delivery network and good equipment for bulk pellet deliveries. Provision of new raw materials and ensuring the good quality of pellets through the whole production, delivery and handling chain will be fundamental in order to increase the use of pellets and sustain the ability to compete with other fuels.

Contents

1. Introduction

Wood pellets have become an important fuel in heat and power production, as they have close to neutral CO_2 emissions, high energy content and they are the first wood based fuels which are

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profitable to transport overseas. Pelletizing condenses the raw materials into compact cylindrical shape pieces, which have typically low moisture content and a high calorific value. The regular geometric size also allows automatic feeding into the boiler, and makes the maintenance as easy as oil heating. However, the advantages of pellets are the lower heating costs, the independence of fossil fuels and that they are more environmentally friendly. The compact size is also advantage in storing and transportation compared with other wood fuels [1,2].

Pellets have become popular in many countries, especially in Europe, where the pellet market is nowadays a large business, and are currently undergoing rapid development. As the pellet markets develop, also the supply side is growing constantly. In some countries, the supply side is growing faster than the domestic use, while others need to import pellets to satisfy the demand. The growing demand for pellets has naturally increased the pellet supply in terms of increased number of pellet plants and the production capacities [2,3]. Ensuring the good quality of pellets through the whole production, delivery and handling chain is important in order to increase the use of pellets and sustain the ability to compete with other fuels, as the quality of the raw materials is one of the factors affecting the quality of the final products. The main raw materials used are by-products from the wood industry, cutter chips and sawdust, which are at the moment utilized so efficiently that alternative raw materials are needed in order to promote further growth in pellet production [3,4]. Some countries with large wood pellet markets have developed national pellet standards but while pellet markets were becoming more international, a need for a common standard has become apparent [5]. At the moment the European Standard for solid biofuels (European standard CEN/TS 14961) is under development and will soon be implemented [3].

The growing demand of pellets has naturally increased the pellet supply. The world's 10 largest pellet producing countries (Sweden, Canada, USA, Germany, Austria, Finland, Italy, Poland, Denmark and Russia) together produced approximately 8.5 million tonnes of pellets in 2007 [2]. In Europe, the leading pellet countries are Sweden, German and Austria, where the pellets production as well as the consumption is large. Other countries, such as Denmark and Italy, are large consumers but the production is small, so they are dependent on pellet imports. On the other hand in Finland, Poland and Russia the domestic consumptions are small and pellet markets are export oriented. Pellets' trading within Europe has also increased steadily and the growing demand has also increased imports from Canada, from where about 765,000 t of pellets were exported in 2007. The largest flows of pellets are from Austria, Finland, Germany, Poland, the Baltic countries and Russian towards Sweden, Denmark and Italy [6,7].

Sweden is the biggest producer as well as consumer of wood pellets in the world [2,3]. In Sweden, three factors affecting the fast development of the pellet industry have been identified: good availability of raw materials, a taxation system favourable to biofuels and extended district heating networks [1,4]. The pellet markets are very developed, with remarkable trade flows [6]. In the early stage of pellet production pellets were mainly used in large heat and power plants but in recent years the small scale sector has grown remarkably. In 2001, large scale users burnt 83% and small scale 17% of the total pellet consumption when today the shares are 47 and 37%, respectively [8,9]. Increasing pellets demand has also increased the number of pellet producers in the country as well as imports from overseas.

In Finland, the pellet market has been export oriented from the beginning, however, recently the domestic consumption has started to increase. Still about 58% of the total pellet production was exported in 2007 whereas in 2006 export was still 75% of the production [10]. The number of pellet users has been increasing slowly but steadily and pellet markets are under constant development but there is still unutilized market potential. The cheap price of pellets has been used as a marketing tool which is now threatened due to the rising raw material prices. Also the lack of subsidies for converting heating system is slowing the establishment of new pellet boilers [2]. In domestic market the most of pellets are used in households 52% and the rest 48% in medium and large scale boilers [10].

The present paper aims to present the current situation of pellet market, raw materials and supply structures in Finland and Sweden. Furthermore, bottlenecks and major drawbacks are highlighted and analysed, and opportunities and future developments of the pellet market are presented.

2. Materials and methods

In order to study the current situation of the pellet production and trade in the countries analysed, a database of the capacity and location of the pellets plants was constructed. The inventory aimed to be exhaustive.

In Finland, the location of the plants was based on the previously collected information by Finnish Forest Research Institute, complemented and updated using the companies' homepages and the companies' official financial reports. In Sweden, the identification and location of the pellet factories was partly based on accounts of pellet producers [11]. Additional sources of information were based on existing scientific literature, company's financial summaries, and companies' homepages.

The collection of information involved direct contacts with pellet producers and pellet associations in both countries, which included interviews to gather data concerning the most common logistic methods. The main associations and companies targeted with the interviews where Svebio (Sweden) and Vapo OY (Finland). Pellet plants planned or under construction were also included in the database, based on official accounts from the companies' reports as well as from newspaper reports. The production, exportation and importation of pellets in Sweden were extracted from PiR [9], and in Finland from Ylitalo [10]. The annual consumption of pellets in Sweden was extracted from PiR [9] and Pellet@las [8], and in Finland from Ylitalo [10].

The location of the pellet plants was geo-referred, using the closets city or town as reference point. In some cases, the precise location was obtained and was used in the location process. The total pellet capacity was aggregated according to the EU NUTS-3 level (Nomenclature of Territorial Units for Statistics), based on the COM (2004) 592 final (CEC 2004) classification [12]. The pellet producers were also classified according to their production capacity.

Finally, a SWOT analysis was implemented in order to analyse the existing raw material and pellet supply chains in both countries, which was the basis of further discussion addressed to the expected trends in production and consumption, and the identification of bottlenecks of the development of the sector in the countries studied.

3. Results

3.1. Pellet production capacity

In Sweden, the first pellet plant started wood pellet production in 1982, and since then, the number of pellet plants has increased to 94 pellet producers (Fig. 1), making Sweden the leading country in the pellet production and the largest wood pellet consumer in the world [2,3]. According to the data analysed, the total estimated production capacity is about 2,344,000 t/yr Of the plants studied, six have an annual capacity equal to or above 100,000 t, while 15 plants have an annual capacity of between 50,000 and 100,000 t, which combined represent over 20% of the producers (Fig. 2). There

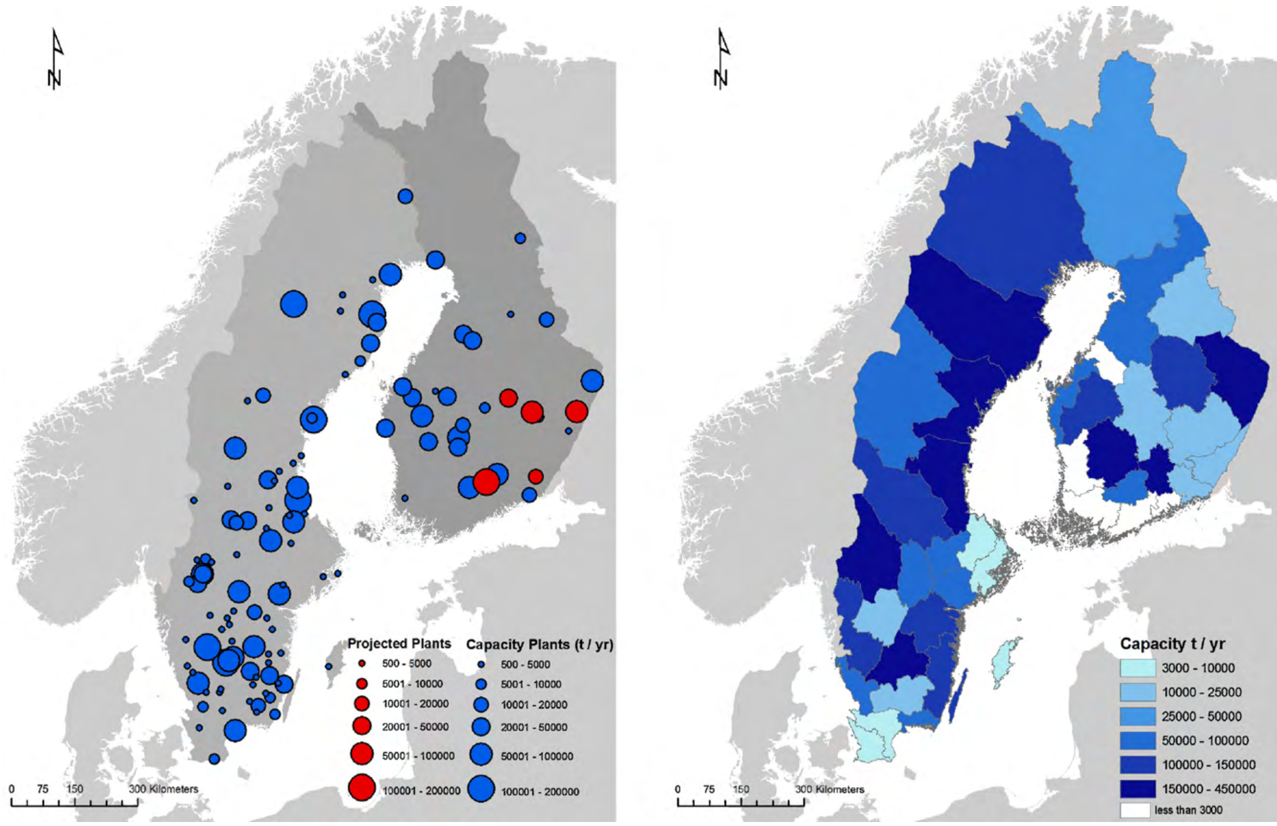


Fig. 1. Location and current capacity of existing and forthcoming pellet plants in the region studied (left) and aggregated capacity by regions (t/yr).

are around 50 small scale pellet producers whose production capacity is from a few hundred tonnes to several thousand tonnes a year. The total combined capacity of the small scale producers (equal or below 5000 t/yr) is about 150,000 t/yr, which means around 6% of the total capacity of the pellet industry in Sweden. In the coming years, a new pellet plant with a capacity of 160,000 t is expected to be built, which would rise the country's total pellet production capacity to over 2.5 million tonnes. By regions, the counties of Jönköping in the South and Västerbottens in the North, have the highest annual capacities, with 342 and 321 thousand tonnes, respectively.

In Finland, the first pellet plant was built in 1998. In 10 years the number of producers has increased to 24, raising the total production capacity to approximately 750,000 t (Fig. 1). There are six plants with a capacity of over 50,000 t, of which one is 100,000 t and four small scale producers (annual capacity under 5000 t). Five new plants are under planning. Once these plants start production, the total production capacity could reach up to 1.16 million tonnes. By regions, Päijänne Tavastia, Pirkanmaa and North Karelia present the highest capacity with 220, 175 and 170 thousand tonnes, respectively. According to the provincial division, western Finland has a total annual capacity of 404.5 thousand tonnes, followed by southern and eastern Finland, with total annual capacities of 325 and 312 thousand tonnes, respectively.

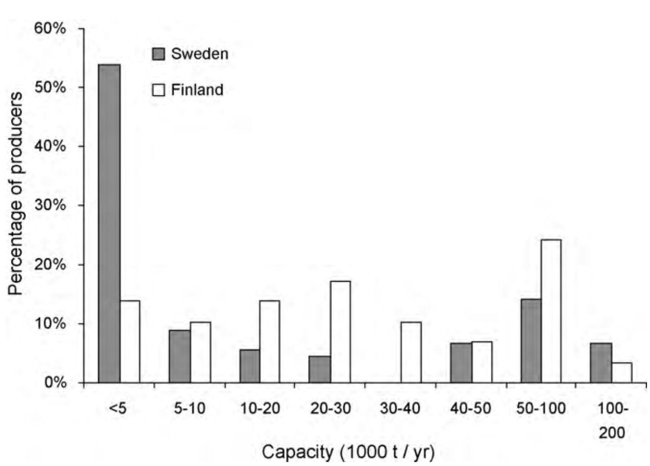


Fig. 2. Distribution of the producers according to their pellet capacity in Sweden and Finland.

The study of the production figures shows that the actual pellet production figures are often lower than the pellet plants production capacities. Many pellet plants, both in Sweden and Finland, are not using their full production capacities. In 2007, the Swedish pellet plants produced around 1.4 million tonnes of pellets in total [9]. However, the domestic production is not enough to meet the demand of pellets, as close to 400,000 t of pellets were imported in 2007 (Fig. 3). Imports are mainly from Canada, Poland and Finland in bulk by large cargo ships. In addition, around 54,000 t of pellets were exported in 2007, mainly to Norway and Denmark [3,4].

On the other hand, in Finland the pellet production was 329,000 t, the estimation for production in 2008 was close to 400,000 t. Since the domestic consumption is relatively small, most of the pellets are exported (see Fig. 3b). In 2006, around 75% of pellets produced were exported, however, due to the rise in domestic consumption, the share of the exports decreased to 58% in 2007. Pellets were mainly exported to Sweden, Denmark and to the Netherlands [10,13,14].

3.2. Pellet consumption

Pellet users can be divided in small, medium and large scale users, according to the size of their boilers or stoves. Small scale

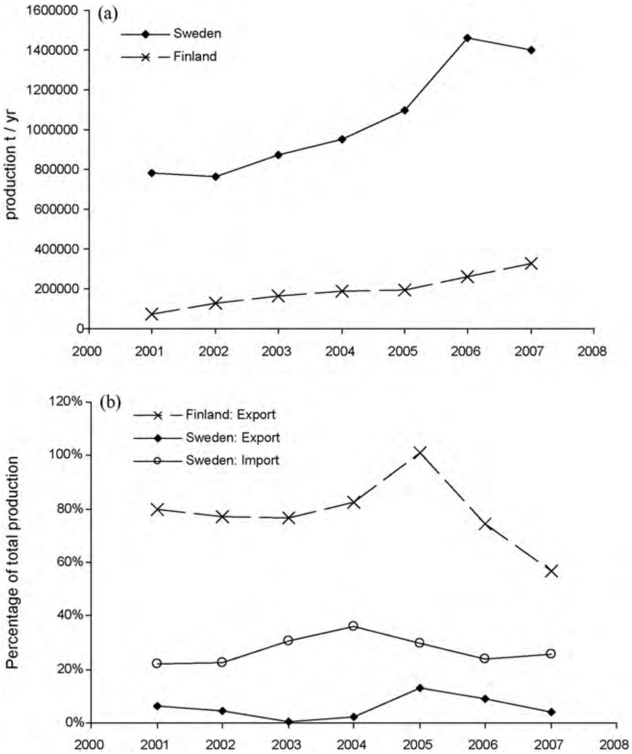


Fig. 3. Production of pellets in Sweden and Finland (a) and rates of exportation and importation of pellets (b).

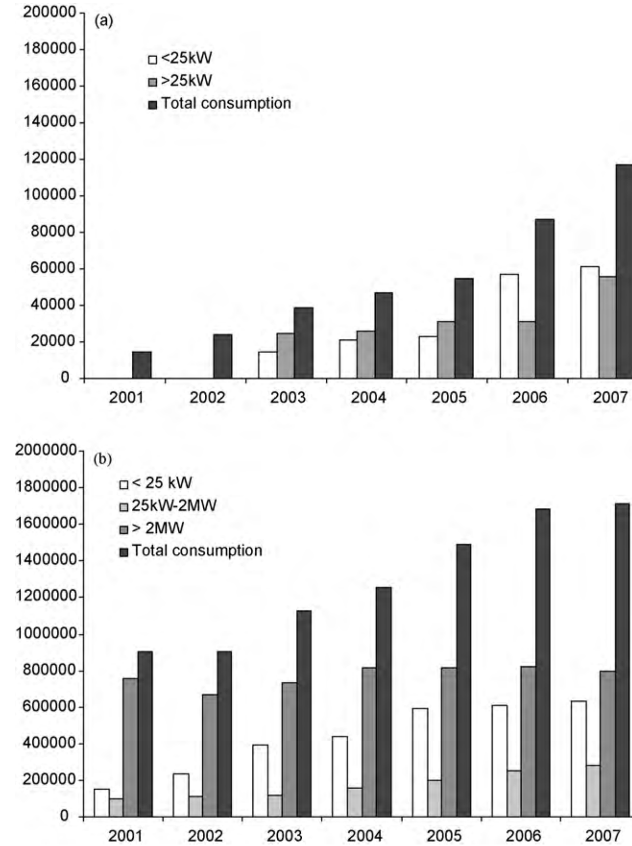


Fig. 4. Annual consumption of pellet (t) in small/residential (<25 kW), medium scale boilers (25 kW–2 MW) and large/heat and power plants (>2 MW) and the total consumption in Finland (a) and Sweden (b).

users are private houses and cottages where pellets are used as the primary heating system or are being burnt in fireplaces. Small scale users are using mainly pellet boilers under 25 kW or pellet stoves or special bucket designed to burn pellets in the normal fireplaces which requires first class quality pellets for fluent combustion. Medium scale users include public buildings, commercial and industrial premises such as schools, greenhouses, health centres, administrative buildings as well as airports whose boiler size is 25 kW–2 MW. Large scale users are districts heating plants and CHP plants whose boiler size is >2 MW. In these large plants pellets are usually combusted together with other fuels and they are pulverized before combusting which allows lower quality requirements compared to small boilers [4,9,13].

In Sweden, the total domestic consumption of pellets was 1,715,000 t of which 635,000 t were used in small scale boilers (<25 kW), 280,000 t in medium size boilers (25 kW–2 MW) and 800,000 t in heat plants and CHP plants in 2007 [8,9]. Large scale users account for about half of the total consumption of pellets, however, the share of smalsl scale users has grown quickly (Fig. 4).

In 1996, about 95% of pellets were mainly used in district heating plants while the number of households using pellets was very low, around 1800 houses throughout Sweden [15]. In 2004–2006 the government was subsidizing small and medium scale heating systems working with biofuels, which increased also the number of pellet users [16]. In 2005 around 80,000 households were using pellet heating systems. The number of small scale users has grown quickly during recent years, e.g., 32,000 pellet boilers and stoves were installed during the year 2006. In 2008 about 120,000 detached houses were using a pellet heating system, in addition to there being about 20,000 pellet stoves in Sweden. Not only the number of private households using pellets has been growing fastest but also the number of medium scale users has also grown; in 2008 there were over 4000 medium scale users [3,8,17]. About 200 district heating plants was using biofuels in heat production, for many of them the main fuel were pellets [18].

In Finland, the total domestic consumption of pellets was 117,000 t in 2007, of which 61,000 t were used in small scale boilers (<25 kW) and 56,000 t in medium size and large scale boilers (>25 kW) (Fig. 4). In the same year the total production was 326,000 t [10]. So far the domestic consumption of pellet has been small compared with other countries using pellets. The consumption of pellets is expected to grow fast in the near future. According to estimations of the Finnish Pellet Energy Association consumption figures for 2012 are: small scale users ~300,000 t, medium scale users ~500,000 t and the large scale users ~300,000 t, which means that the total consumption is estimated to be over 1 million tonnes over the current production in the near future.

In general, the number of pellet users has been growing slowly. In 2001, only about 300 households were using pellets [19]. The number of small scale pellet users in 2003 was 1000–2000 users, with the number growing with 400–500 new users per year. Approximately 15,000 households were using pellets in 2008, additionally a few hundred public buildings, schools and industrial buildings were using pellets heating systems and a few dozens heat and CHP plants were combusting pellets for energy production [14].

3.3. Pellet logistics

In the studied countries, raw materials are mainly domestic by-products of the wood processing industry (cutter chips and saw dust). Some small amounts of saw dust are imported to Finland from Russia and to Sweden from Finland by trucks [4,7]. Most of the pellet plants are next to their raw material supply (saw mill, wood industry, furniture industry, etc.) which is lowering the raw material transportation costs. Many small and medium scale pellet

plants are working together with local partners which are then the source of raw material. In the case of very short transport distances conveyors or pneumatic systems are used to transport raw material to the pelletizing lines. Larger producers are mainly collecting the raw materials from several wood processing places in the surrounding areas of the pellet plant; transport is done mainly by trucks. Raw materials are emptied from the trucks to open air field storages which are coated with asphalt or to warehouses, from where they are moved to production lines with loading shovels or by conveyors. Raw materials arriving to the pellet plant are stored inside if the plant does not have dryers and outside if there is dryer. Typically only the largest pellet plants have dryers when small and medium producers are mainly using dry raw materials. From the storage the raw materials are usually carried by a conveyor, feed screw, pneumatically or with loading shovel to the pellet production line. If raw material is coming from several places, it is usually sieved and a magnetic separator is used of the removal of foreign particles.

Handling of the pellets at the plant site is similar both in Finland and Sweden. The share of different delivery types is probably affected to the equipment used in the pellets packing process. Pellets are stored at the plant site in large silos or in warehouses for bulk deliveries and packed to small and large sacks. Pellets' packing to large and small sacks is usually done straight from the pelletizing line or if pellets are packed later from warehouse they are sieved again before packaging.

In Sweden, small sacks are the most popular way for households to purchase pellets. Pellets' packing in large plants as well as in small plants is efficient and automated. Some of the small producers only pack pellets to sacks and do not have bulk deliveries. Small sacks are filled with pellets (16 kg) and sealed automatically, a roller conveyor moves the sacks to an automatic packing device which places the sacks on a pallet (often 52 sacks per pallet), and finally wraps them with stretch film. Since small sacks are polythene, which is water-resistant, they can be stored outside and no special storage needs to be built. Large sacks are stored in warehouses on top of loading pallets, to prevent water infiltration from the floor. Medium and large pellet producers are storing pellets for bulk deliveries in silos or warehouses.

In Finland, the small sacks share of all pellets deliveries is very small, they are mainly done by orders, due to this in most of the pellet plants small sack packaging is not automated but requires hand work at some level. Most of the producers are selling pellets in large sacks and in bulk. Some pellet producers have not invested to packing devices since most of the production is sold in bulk.

Bulk pellets are stored at the pellet plant in silo storages and/or warehouses both in Finland and Sweden. Bulk deliveries are loaded from the silo storage to pneumatic trucks or with loading shovel to normal trucks. Export is done by train from the pellet plants which have a rail connection. Trains transport pellets to the harbour where they are shipped for export. In Sweden, many plants are located on the coast and pellets are shipped straight from the plants for export as well as for domestic markets.

In Sweden, for domestic household consumers about 80% of pellets are delivered in sacks while only 20% are delivered in bulk with pneumatic trucks, to medium and large scale consumers all pellets are delivered in bulk by trucks or large cargo ships. Large producers are delivering bulk pellets as well as sacks, when many of the small scale producers are only delivering pellets in small sacks. Pellets sacks are also sold through retailers since not all pellet producers sell pellets straight from the plant. In Sweden, there is an extensive retailers' network, pellet sacks are sold in places such as pellet heating specialist, chimney-sweeping companies, oil-distributors, do-it-yourself stores, farmer's equipment stores, and plumbing firms. Pellets prices of different delivery types and producers are easy to compare since most of the information is available online (e.g. at www.pelletspris.com, over 100 retailers and pellet producer have collected their prices). Pellet heat can be delivered straight to the customer from a small scale centralized pellet heating centre, a container solution, in which case customer does not need to do maintenance work or buy pellets.

To large scale consumers, such as a heat plant located on the coast, pellets are transported by cargo ships either local pellet plants or from abroad. In the European market area ship-loads are typically 4000–6000 t, with the overseas shipments being done in large volumes of usually 20,000–30,000 t [20,21]. A small part of the imported bulk pellets are sieved from fines and are packed into small sacks in Sweden and also occasionally sacks are delivered from Finland.

In Finland, the main delivery method of pellets was bulk delivery. In about 71% of all the deliveries pneumatic or normal trucks have been used. The share of sack deliveries is small, with large sacks representing 25.5% and small sacks only 3.5% of all deliveries. Producers are selling directly from the plant, or via small retailers which are often selling pellet boilers and other pellet related equipment. Retailers are only selling the pellets in sacks (both small and large sacks). Exports are mainly done in bulk by ships from the main harbours; both sea and lake harbours from Inkoo, Loviisa, Joensuu, Oulu, Kokkola and Kaskinen. A typical shipment is between 2000–4000 t [13]. Small amounts of sacks are exported by trucks mainly from North Finland to Sweden.

Pneumatic trucks are used when delivering pellets to households or medium size customers, for large scale users pellets are delivered by large normal trucks. The equipment for bulk deliveries varies; from normal trucks and specially designed pellet tanker trucks, to existing machinery used for animal feed deliveries. New trucks have an integrated weighing scale which allows accurate delivery and billing. The minimum amount of bulk deliveries is in most cases around 3 t. The containers of older trucks are divided into smaller sections for suitable delivery amounts. The length of the unloading pipe, pressure and power used during unloading and the model and conditions of the delivery trucks, as well as the experience of the driver, affect the quality of the pellets during transport and delivery [22,23].

4. Discussion

4.1. Expected trends in pellet production

Currently, there is an important lack of official statistics on pellet production and trade, which makes difficult the study on the development of pellet markets. This paper provides aims to fill this gap for Sweden and Finland. Although the aim of this paper is to have the closest possible analysis of the current situation of the pellet sector in Sweden and Finland, it is possible that some pellet producers have not been included in the data explored. However, the number of pellet producing plants included was larger than in other accounts [8] and offers a solid base for analysis.

Concerning Sweden, although there are already nearly 100 pellet producers, also new plants are currently under planning. For instance, one plant is expected to start operating during 2009 [24], and according to estimates from Svebio, 3–4 large scale pellet plants could be built during the next 5–10 year period.

According to the data presented, in Finland there were 24 pellet plants operating in 2008, with five additional plants planned or being constructed. This will raise the estimated production capacity of 1.16 million tonnes, which is in line with the estimations of 1 million tonnes of production in 2010, made by the Finnish Pellet Energy Association [14]. The total production estimate for 2020 is 1.5 million tonnes of pellets which would

Table 1
SWOT analysis of existing raw material and pellet supply systems in Finland and Sweden.

Finland	Sweden	Finland	Sweden
Strengths		Weaknesses	
Enough domestic production to increase the number of pellet users	Develop pellet market	Lack of good quality raw materials	Lack of raw materials
Domestic raw materials	Many small scale producers	No pellet standard	Many small producers do not follow any standards
	Well develop delivery network	Amount of fines formed in bulk deliveries	Quality of imported pellets (amount of fines)
	Most of the pellets produced according to pellet standard	Taxation	
	Favourable taxation		
Opportunities		Threats	
Development of pellet handling and transportation	New raw materials	Decreasing sawmill production effect on raw material availability	Competition for raw materials with other industries
Make pellet market local instead of global	Improving the harbour facilities for handling imported pellets	Rise in the pellet price	Rise in the raw material price
Increase the domestic pellet consumption		Uncertainty of raw material supply can delay forthcoming plants	Reduction in pellet importation
New raw materials			

require establishing new pellet plants or enlarging the existing plants [14,25].

4.2. Expected trends in consumption

In both countries studied, a significant part of the pellet users are private households. In Sweden, the small scale pellet users are expected to be households moving from direct electricity and water-distributed electricity heating to the pellet heating systems. The potential is also significant since together there are almost 570,000 households using these heating systems which means in the near future there could be almost 700,000 households using pellets [4,26]. The number of small and medium scale pellet users is also expected to keep on growing in the near future, whereas the number of large scale users is not expected to grow remarkably. On the opposite trend, the large scale CHP plants might replace part of the fuel pellets with forest residuals [27].

According to the Finnish Pellet Energy Association, the number of households using pellets in the future could be five times more than at present. In fact, there is a lot of potential since today Finland has only around 15,000 household using pellets. There is a growing interest in pellet heating and the estimates for 2012 is that there would be 50,000 households using pellets [13,14]. Most of the new users would come through restoring the old oil heated houses as well as the builders of new houses choosing pellet heating system. Additionally, because of the high price of the electricity some of the electrically heated houses could be encouraged to change to pellet heating. In 2006 there were around 290,000 residential buildings using oil heating and around 470,000 were heated with electricity [26,28]. Pellets are expected to replace some of the firewood used in the fireplaces; this is supported by the increase in sales of pellet stoves and pellet baskets for use in fireplaces.

There are currently a few hundred medium scale users including public buildings, schools, monasteries and airports. In addition, there are a few building projects of terraced houses which will have centralized pellet heating system [29]. Large scale users are the heat plants and district heating plants. In Finland the number of district heating plants is not likely to grow since the network is already economically efficient. Instead the number of plants using pellets and the share of pellets used in the plants can be higher [30]. According to the vision of the Finnish Pellet Energy Association, pellet users in 2012 would include 50,000 small users (households), around 2000 medium size users (public buildings, industry) and 100 large users (heat plants), the use of pellets is estimated to be 300,000, 500,000 and 300,000 t, respectively. The estimation for heat plants is for the ones using mostly pellets as fuel or mixed with other wood fuels.

The development of pellet users is also depending on the taxation of fossil fuels. At the moment the total heating cost difference between the pellets and fossil fuels is relatively small [3]. In contrast with Sweden, in Finland, the government is not providing subsidies to private households for changing to pellet heating systems, which is partly slowing the pellet heating system development. Without subsidies the investment cost of changing to pellet heating system can be very high [14].

4.3. Identified bottlenecks for the development of the sector

4.3.1. Raw material supply

In the coming years, a serious limitation to the development of the sector will be the shortage of raw materials (Table 1). A lack of insufficient good quality raw materials for increasing production has been predicted [31]. This in return could raise the pellet prices in the future. In Finland, due to a recent decrease of the number of sawmills, there has been a lack of raw materials for pellet production during the winter 2008–2009 [32]. Additionally, particleboard and fibreboard industries are increasingly competing with pellet plants for raw materials.

Current developments of Russian wood tariffs on timber exports are reducing the expected amount of round-wood coming to sawmills in Finland. The outcome of these measures adds uncertainty to the development of the sector, as it can potentially reduce the sources of raw material for pellets [13,33].

New cost efficient raw materials are needed both compatible with existing pellet production structures and users' equipment (storages and boilers) and within reasonable transportation distances. Amongst possible alternatives, the use of bark for pellets has been considered. However, its role is limited since it can only be used in the larger boilers due to the high ash content [28,34] and is often combusted at the debarking place, typically in pulp mills, or used for higher added values purposes such landscaping and gardening [25]. Even though in Sweden, one pellet plant is producing bark pellets, they are all combusted in one large CHP-plant.

Numerous alternative raw materials for pellet production are under research, but many of them present limitations for small scale producers, or even on a medium scale since the drying costs are high, and not enough pellets can be produced to be economically efficient [35]. Forest residues, e.g., have a large potential, but the handling and drying need to be carefully studied, in order to decrease the corrosive agents which can cause problems in small scale boilers [34]. Another possible source of raw material are energy crops such reed canary grass and short rotation woody plantations. Currently, Finland has around 20,000 ha of reed canary grass under production. Sweden is the leader in commercial plantations for bioenergy purposes in Europe, presenting around 16,000 ha of short rotation willow plantations established, which means about 0.5% of the total arable land in the country. In Sweden, short rotation coppice is at the moment mainly combusted in large scale boilers as chipped, although its possibilities for pelletization are under current research, presenting broad possibilities for biofuel trade [36].

4.3.2. Pellet logistics and transportation

Transportation costs of raw materials can be very high as distances are often very long. For small/medium scale producers, the profitable pellet delivery radius is about 300 km. In Finland, the pellet supply needs to be directed to the domestic markets instead of the export market if the number of pellet users is growing in the future. There are sufficient pellets produced which could be used on the local market instead of being transported abroad. The pellet production for 2008 could be used for heating around 75,000 detached houses, but at the moment there are only 15,000 houses heated with pellets [14]. Increasing the number of users in the domestic market will require the development of a transportation network and associated equipment, mainly pneumatic trucks for bulk deliveries, for good and fast pellet delivery.

Currently, a typical pellet delivery is 2 weeks from the ordering time and the delivery equipment varies from purpose built pneumatic trucks to existing animal feed delivery trucks. The main complaint from the users is the amount of the fines that pellets delivered in bulk sometimes contain. Pellets disintegrate during long distance transport and loading and unloading which can increase the amount of fines and reduce the pellets' quality [22]. For the domestic market a large share (71%) of the pellet deliveries are done in bulk which, compared to sacks deliveries, is causing more crumbling. The main reason is probably the use of old trucks not designed for pellet deliveries and the unloading method. However, bulk deliveries are more economic, efficient and cheaper than deliveries of small sacks. In Finland, there are no standards for pellet deliveries and not all transport workers are trained to handle pellets. A large amount of research has been done regarding the handling of pellets and machinery used to minimize pellet crumbling during pneumatic deliveries with some recommendation being made (e.g. [22,37]).

In Sweden, a large share of the pellet imports are from Canada which means long transportation distance and higher delivery costs; therefore it is more profitable to buy large volumes. The cost of sea transportation from Canada to Europe can be up to 56 CAN$/t of pellets [38]. The majority of pellets exported to Sweden are coming from the interior of Canada, which requires trains to deliver them to the harbours on the east coast where pellets are shipped to Europe [39]. In addition, imports done by ship means extra loading and unloading of the pellets causing more fines and pellets are easily exposed to moisture depending on the loading process and facilities. Imported pellets are mainly used by large scale users, heat and power plants, where pellets are crushed before combustion. However, for small scale users of imported pellets the fines need to be separated. The main logistical problem is the storage needs at both ends; since shipping is done in large amounts (typically from 7000 up to 30,000 t) therefore large storage spaces are needed at the harbour facilities [21].

4.3.3. Standardization efforts

Finally, an additional bottleneck is the lack of standardization among small scale pellet producers, mainly in Sweden. Most of them do not currently follow any standards, although there are increasing numbers of producers following the Swedish standard. Small producers are selling pellets to households where mainly small scale boilers (under 25 kW) are used, which require good quality pellets to work efficiently and fluently [4]. When the EU standard is applied it is possible some small scale producers would be required to improve their production to meet the standards. On the other hand, the small scale producers are mainly using good quality raw material, cutter chips, in their production in which case following the standard should not be a problem.

5. Conclusions

Pellets are still a relatively new fuel, and its initial popularity has been based on cheap prizes, low carbon emissions compared to fossil fuels and the use of local energy sources supporting the energy independence from mainly oil and gas. Furthermore, fully automated pellet stoves are able to compete with oil stoves in regards to maintenance. The conception of wood being a dirty and messy fuel requiring lot of manual labour has been overcome with the use of pellets. In Sweden, pellets have become increasingly popular, due the energy policy framework concerning fuel taxation and subsidies. In Finland, the past policies have not promoted pellets to the same extend than Sweden, and the development on the consumption side has been slower. Recently, subsidies are also available for the upgrading to new heating systems which should further boost the small scale use of pellet stoves in Finland.

In both countries, small scale pellet producers are typically producing pellets as a by-product from their main business, whereas middle and large scale producers are intensively concentrating on pellet production. From the market point of view, Sweden and Finland still have significant capacities to increase their production, as well as the consumption of pellets. In the near future, standardization of pellets will help to promote pellets for the small scale consumers, which will offer increasing possibilities for expansion.

However, one of the main challenges for the coming years will be the supply and development of new raw materials for pellet production. The current focus of research is to broaden the raw material base for pellet production in order to secure pellet supply to particularly small scale customers and to ensure price stability in the future. This will be essential to built trust among the general public which is still critical towards this new and young technology.

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